STEP rapport / report

ISSN 0804-8185

R-10 • 1996

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Technology acquisition by SMEs in Norway

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Paper prepared for SMB-analysis programme, Research Council of Norway

Oslo, September 1996

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1. Introduction

An important policy issue with respect to small firms is whether such firms require support in accessing technologies and technological knowledge outside the firm. This paper is a statistical study of technology acquisition by Norwegian firms. It looks at two basic issues:

- are there important differences between small firms and large firms in the *extent* to which they acquire outside technologies?
- are there differences between small firms and large firms in terms of the types of 'channels' through which technology is acquired?

These questions relate to two policy issues. Firstly, is there a case for the view that small firms need support in acquiring outside technologies? Secondly, are there particular channels of support which might need to be strengthened for small firms?

Answering these questions in fact involves some quite complex statistical issues, mainly to do with controlling for differences in innovativeness among different size classes of firms, and controlling for the fact that firms operate in different industries. The main analytical part of this paper addresses these problems. To anticipate the conclusions of the paper, we show that there is a clear tendency for the share of firms who acquire outside technology to rise across size classes. Given that it is usually believed that SMEs have a greater need for external technology inputs than large firms, this suggests a role for policy. However we also show that there are no significant differences between small and large firms in terms of the relative importance of channels of technology acquisition. This suggests that the design of policies in this field does not need to discriminate between target groups of different size.

2. The role of technology acquisition

One of the key insights of modern innovation theory is that firms rarely innovate on the basis of internal resources only. Instead, they draw on knowledge, skills, technical solutions, methods and equipment from outside the firm itself. Most innovating firms have complex webs of relationships with customers, suppliers, research institutes, industry associations and so on which are used to solve the many technical, organizational and financial problems which are presented by any attempt to innovate. These processes of interdependence have led to a wide set of models of innovation based on 'interactive learning' between firms and their wider environments.

Our understanding of the importance of interactive learning is not based simply on case studies. One of the most robust results from recent European surveys on innovation is that firms which are involved in formal cooperation arrangements tend to innvate significantly more: they have much higher shares of new products in their sales profiles than firms which do not undertake collaborative R&D or technology development.[1]

Acquiring technology from outside the boundaries of the firm is a critical problem for all innovating firms, but it is especially important for SMEs. On the basis of previous research on SMEs, particularly on the basis of statistical analyses, we know that very few SMEs perform R&D (and even fewer do so on a continuous basis), very few commit significant financial resources to innovation, and very few have a broad range of skills and qualifications within their workforces.

It is therefore very important to understand more about the nature of technology acquisition, particularly in SMEs. Firms can acquire technology and technological knowledge in a range of ways. They can, for example, acquire technologically advanced equipment, and learn - in more or less formal ways - to integrate it into their production processes. They can use consultants, they can licence patented information from other firms, they can engage in know-how trading or information acquisition from other firms, they can employ people with specific skills, they can buy in skills by merger and acquisition activity, or they can undertake joint R&D work, for example.

How important are these various types of technology acquisition? This paper gives an overall statistical picture of the pattern of technology acquisition in Norway, focusing on SMEs. The basic objective of this paper is to go beyond case studies into a wider picture of the relative importance of various types of technology acquisition methods, with the ultimate objective of helping to identify the policy implications.

[1]For the Norwegian data on this point, see Nås, Sandven and Smith**, Innovasjon og ny teknologi I norsk industri: en oversikt**, STEP Report 4/94, Figure 10.7, p.67. For Europe-wide data, see European Commission, *Green Paper on Innovation,* **Bulletin of the European Union Supplement 5/95**, Table 22, p.92

3. The Data and the Questions

As noted above, this paper uses data from the Norwegian Innovation Survey 1993 concerning transfer of technology. More specifically, the data covers whether firms in the sample have acquired new technology or not during a particular year (1992), and if so, through which ‘channel’ they have acquired new technology. This means acquiring new technology *from outside the firm*, as opposed to having created the new technology inside the firm itself. Thus, the data concern *diffusion* of new technology through different channels, looked at from the *receiving* end of the diffusion processes. The study is limited to firms within the *manufacturing* sector.

Our focus on differences between large and small firms, or, more generally, on differences among different size classes of firms. We ask the following main questions:

- Firstly, are there differences between small and large firms when it comes to how active or innovative they are in terms of acquiring new technology from outside the firm?
- Secondly, are there differences between firms of different size classes when it comes to the relative importance of different ways of technology acquisition? Are some ways of technology acquisition more important among small firms while other ways are more important among large firms? In other words, are there differences between small and large firms when it comes to the relevance of different diffusion channels?

Clearly, answers to these questions should be of interest from a policy perspective.

The data we will analyse are answers to altogether eight questions of whether the firms in the course of 1992 have acquired new technology through one or more of altogether seven specified ways plus the residual category ‘other’.

Thus, the firms are asked if they in the course of 1992 have acquired new technology through one or more of the following ways:

(a) *the right to use the innovations of others (including licenses)*;
(b) *the results of R&D performed by external contractors*;
(c) *the use of consultancy services*;
(d) *the purchase of (the whole or parts of) other firms*;
(e) *information or special services from other firms*;
(f) *the purchase of equipment*;
(g) *hiring of qualified personnel*;
(h) other.

The firms are only asked to tick the relevant box if the answer is ‘yes’, except for the residual category, where they are also asked to specify.

There are in fact four different boxes for each question, corresponding to a question about the location of the source of the new technology: whether the firm has acquired new technology through the way in question from Norway, from the Nordic area, from the EU (excluding Denmark) or from areas outside the EU. However, we will not consider this dimension of the geographical location of the sources of the new technology. We will simply consider whether the firm in question has or has not received new technology in each of the ways specified, irrespective of the location of the source and of whether only one location or more than one are indicated.

Thus, disregarding the question of the geographical location of the sources of new technology, the data say whether or not the firms in the course of 1992 have acquired new technology through altogether eight different ways, including the residual category (‘other’). Some firms have *not* indicated acquisition of new technology during 1992 at all, some firms have indicated that they have acquired new technology through *one* of the ways only while some firms have indicate that they have acquired new technology through more than one way. The maximum number of ways indicated is seven, as no firms have indicated all the eight ways.

Let us turn to the definition of firm size classes. We use number of employees at the end of 1992 as the variable defining firm size, and we have divided this into five different size classes. They are the following: (i) less than 20 employees; (2) 20-49 employees; (3) 50-99 employees; (4) 100-299 employees; and (5) 300 or more employees.

4. Are there differences in technology acqusition between SMEs and large firms?

We now begin exploring the data, looking first at the general links between firm size on technology acquisition. In our study there are 954 manufacturing firms. Let us first look at the share of the firms inside each size category who report that they have acquired new technology in the course of 1992 at all, irrespective of through which way or of how many different ways they have indicated. This is shown in Table 1, below.

Table 1. **Number and share of the firms inside each size category who have acquired new technology during 1992**.

	Size category: number of employees					
	under 20	20-49	50-99	100-299	300 or more	total
N	423	167	132	155	77	954
Acquired new technology	56	54	54	81	57	302
Share (per cent)	13.2	32.3	40.9	52.3	74.0	31.7
Share size category/share total	0.42	1.02	1.29	1.65	2.34	1.00

302 of 954 firms, or 31.7 per cent of all firms, report that they have acquired new technology in 1992. This share rises sharply and consistently as we go from the smallest to the largest firms, being only 13.2 per cent among the firms with less than 20 employees and 74 per cent among the firms with 300 employees or more.

The statistical significance of these differences has been tested by means of an analysis of variance (ANOVA). Having acquired or not acquired new technology is thus treated as a dichotomous variable, with values 1 (have acquired new technology) and 0 (have not acquired new technology). As a whole, these differences are of course highly significant, the probability that we should have found differences of this magnitude among the groups had there in fact been no differences among them being less than 0.0001. Comparing the size classes two and two by means of Tukey's Studentized Range Test we find that most of the differences are significant at the 5 per cent level, apart from the difference between the 20-49 employees category and the 50-99 employees category and between the 50-99 employees category and the 100-299 employees category.

The shares reported in Table 1 above are based on *all* firms in the survey. However, all the firms who report acquisition of new technology belong to a special subsection of our sample defined by the answers to three preliminary questions in the questionnaire. These three questions are: (i) Has the enterprise developed or introduced any technologically changed or new products during 1990-92? (ii) Has the enterprise developed or introduced any technologically changed or new processes during 1990-92? (iii) Does the enterprise plan to develop or introduce any technologically changed or new products or processes during the period 1993-95? If the answer to at least one of these questions is ‘yes’, the firm is asked to answer *all* the questions in the questionnaire. If, on the other hand, the answer to *all* three questions is ‘no’, the firm is asked to skip most of the questions, and is thus not even asked to answer the questions about acquisition of new technology.

Let us term ‘innovative firms’ those firms who have answered ‘yes’ to at least one of the preliminary questions and who are thus asked to answer the questions on acquisition of new technology. Table 2, below, shows the share of the firms inside each size category who are innovative in this sense.

Table 2. **Number and share of firms inside each size category who report innovation activity**.

	Size category: number of employees					
	under 20	20-49	50-99	100-299	300 or more	total
N	423	167	132	155	77	954
Number of innovative firms	114	76	75	109	67	441
Share (per cent)	27.0	45.5	56.8	70.3	87.0	46.2
Share size category/share total	0.58	0.98	1.23	1.52	1.88	1.00

We see that less than half the firms, or 441 out of 954, report innovation activity and are thus asked to answer the questions on acquisition of new technology. However, again the shares vary very substantially with size class. Moreover, the share rises unambiguously with firm size, being 27 per cent among the smallest firms and 87 per cent among the largest.

Again, by means of an ANOVA test we find these differences as a whole highly significant, the probability that we should have found differences of this magnitude among the groups had there in fact been no differences among them being less than 0.0001. Also, comparing the size classes two and two by means of Tukey’s Studentized Range Test we find that most of the differences are significant at the 5 per cent level, apart from three. These are (i) the difference between the 20-49 employees class and the 50-99 employees class, (ii) the difference between the 50-99 employees class and the 100-299 employees class, and (iii) between the 100-299 employees class and the 300 or more employees class.

The next step is to examine the share of the *innovative* firms inside each size class who have acquired new technology. This is shown in Table 3, below.

Table 3. **Number of firms inside each size category who have acquired new technology during 1992, share of the innovative firms inside each size category who have acquired new technology**.

	Size category: number of employees					
	under 20	20-49	50-99	100-299	300 or more	total
N innovative	114	76	75	109	67	441
N acquired new technology	56	54	54	81	57	302
share (per cent)	49.1	71.1	72.0	74.3	85.1	68.5
share size category/share total	0.72	1.04	1.05	1.09	1.24	1.00

To repeat, this time the 441 firms who report innovation activity are the basis of the calculation, and we look at the share of these firms who report having acquired new technology in 1992. The overall share here is 68.5 per cent, 302 of 441 or a little more than 2/3. Again we see that this share without exception rises as we go through the size categories from the small to the large firms, being 49 per cent among the smallest firms and 85 per cent among the largest. However, the differences among the middle categories are not large at all.

An analysis of variance again reveals these differences as a whole to be highly significant, the probability that we should have found differences of this magnitude among the groups had there in fact been no differences among them being less than 0.0001. However, this time a Tukey’s Studentized Range Test shows that only four of the ten differences between two and two shares are significant at the 5 per cent level. These are all the four differences between the less than 20 employees category and each of the other size categories. None of the other differences are significant at the 5 per cent level.

The general point here is that both in the sample as a whole, and in the subset of innovative firms, SMEs are less likely to acquire technology outside the firm. This is consistent with the view that SMEs face problems in this area, and may suggest a broad role for polucy intervention.

5. Do SMEs use fewer sources of technology acquisition?

We now focus our attention exclusively on the 302 firms who report having acquired new technology in the course of 1992, and aske whether firm size makes a difference in terms of the number of sources through which firms acquire technology. As was mentioned above, some of the firms report having acquired new technology through only one of the ways indicated while others report having acquired new technology through more than one way. Table 4, below, shows the average number of ways reported by the firms inside each size category.

Table 4. **Average number of ways of acquiring new technology reported among the firms reporting acquisition of new technology, by size class**.

	Size category: number of employees					
	under 20	20-49	50-99	100-299	300 or more	total
N acquired new technology	56	54	54	81	57	302
Sum number of instances	95	123	123	207	165	713
Average number of instances per firm	1.7	2.3	2.3	2.6	2.9	2.4
Average size class/average total	0.72	0.96	0.96	1.08	1.23	1.00

We see that among the 302 firms who have reported acquisition of new technology, there are altogether 713 instances of reporting of acquisition of new technology. Consequently, the average number of ways of technology acquisition among these firms is 2.4. Note again that the number of instances reported for each firm only tells us about the number of ways of technology acquisition which have occurred at least once during 1992 and nothing else. It tells us nothing about the relative importance of each way of technology acquisition e.g. in terms of costs or of how many times the different types of technology acquisition have occurred. For each firm we have only registered whether each of the different ways of acquisition of new technology occurred or not.

Again we see that the occurrence of acquisition of new technology, here measured as the average number of ways of acquisition per firm, tends to increase with increasing firm size. The only exception is that the average is exactly the same in the 20-49 employees category as in the 50-99 employees category.

Also here we have tested the statistical significance of these differences by means of an analysis of variance. Again we find the differences as a whole highly significant, the probability that we should have found differences of this magnitude among the groups had there in fact been no differences among them again being less than 0.0001. However, comparing the size classes two and two by means of Tukey's Studentized Range Test we find that only two of the ten differences are significant at the 5 per cent level. They are the difference between the less than 20 employees category and the 300 or more employees category and between the less than 20 employees category and the 100-299 employees category.

To sum up so far, we have looked at the share of all firms who report innovation activity, then at the share of firms with innovation activity who report having acquired new technology, then at the average number of ways of acquiring new technology reported by the firms who have acquired new technology. We may see this as going successively from all firms through the firms who report innovation activity to the firms who report having acquired new technology and finally to the total number of ways of acquiring new technology reported. We have found that in every step of this progression there is a clear tendency for the share or the average value to increase with increasing firm size.

This is summed up in Table 5, below, where the shares accounted for by each size category of, respectively, total number of firms, all firms who report innovation activity, all firms who have acquired new technology and all instances of acquisition of new technology, are shown.

Table 5. **Share accounted for by each size category of total number of firms, of all firms who report innovation activity, of all firms who have acquired new technology and of all instances of acquisition of new technology**.

	Size category: number of employees					
	under 20	20-49	50-99	100-299	300 or more	total
Share of all firms	44.3	17.5	13.8	16.2	8.1	100
Share of firms with innovation activity	25.9	17.2	17.0	24.7	15.2	100
Share of firms who have acquired new technology	18.5	17.9	17.9	26.8	18.9	100
Share of instances of acquisition of new technology	13.3	17.3	17.3	29.0	23.1	100

We see that while the less than 20 employees category has 44.3 of all the firms in the samples, this share decreases successively until it is down to only 13.3 per cent of all instances of ways of technology acquisition. Conversely, for the 300 or more employees category there is a corresponding increase, from 8.1 per cent of all firms to 23.1 per cent of all instances of ways of technology acquisition.

This also emerges from Table 6, below, where the cumulated shares accounted for by size categories ranked by increasing size, of, respectively, total number of firms, all firms who report innovation activity, all firms who have acquired new technology and all instances of acquisition of new technology are shown

Table 6. **Cumulative shares accounted for by size categories ranked by increasing size, of, respectively, total number of firms, all firms who report innovation activity, all firms who have acquired new technology and all instances of acquisition of new technology**.

	Size category: number of employees				
	under 20	20-49	50-99	100-299	300 or more
Share of all firms	44.3	* 61.8	75.7	91.9	100
Share of firms with innovation activity	25.9	43.1	* 60.1	84.8	100
Share of firms who have acquired new technology	18.5	36.4	* 54.3	81.1	100
Share of instances of acquisition of new technology	13.3	30.6	47.8	* 76.9	100

The median category in each case is marked by an asterisk. We see that among all firms, the median is in the 20-49 employees category, while both among the subset of firms who report innovation activity and the further subset who report that they have acquired new technology it is in the 50-99 employees category, and among all instances of reporting of ways of technology acquisition it is in the 100-299 employees category.

In conclusion, there is a very clear tendency for the share of firms who have acquired new technology to increase with increasing firm size. When we extend the focus to look at the number of ways of acquisition of new technology reported per firm this conclusion is strengthened, since among the firms who have acquired new technology, the average number of ways reported increases with increasing firm size.

Now, acquiring new technology is obviously an aspect of being innovative. In this sense, and given the measure that we are using here, it clearly turns out that the larger the firms, the higher the share of firms who are innovative.

6. The importance of technology acquisition: basic issues and problems

However, even given that we here limit our attention to the acquisition of new technology, the sense of being innovative which we are measuring here is a very restricted one. What we measure here is the mere *occurrence* of having acquired new technology through each of the different ways during one particular year. This measure says nothing about the relative importance of the new technology acquired, for instance in relation to the total activities of each firm. It might, for instance, be the case that there was much larger diversity among the small firms than among the large firms. It might be that although very many large firms reported acquisition of new technology, and even several ways of acquisition of new technology, in most cases the new technology acquired only affected a small share of the total activity of the firm. For small firms, on the other hand, it might be that in the relatively much fewer cases where firms report acquisition of new technology, there was a tendency for the new technology acquired to affect a much more important share of the total activity of the firms than what was the case among the large firms. Thus, *another* measure of innovativeness in relation to the acquisition of new technology, requiring a certain importance of the new technology in relation to the total activity of each firm, might find that there was a higher share of innovative firms among the *small* firms than among the large firms. The point here is that the data do not tell us anything about this. Such a possibility is not inconsistent with our data.

On the other hand, we have no *specific* reason to suppose that this possibility is in fact the case. What is certain is that given the reporting of the occurrence of acquisition of new technology, the relative *importance* of the acquisition will vary substantially across firms, covering the whole spectre from a minor transformation of a small part of the firm's activities to major transformations of the whole production process. However, we have no specific reason to suppose that this will vary systematically across size categories.

Thus, we should be aware of the limitations of the measure of acquisition of new technology used here. But to the extent that we do not have any specific reasons for assuming that the relative importance of the new technology acquired given the occurrence of acquisition of new technology varies systematically across size classes, it will not be too problematic to use this measure for comparing acquisition of new technology across size classes. By the same argument, the average *number* of ways reported in each size class should give some additional indication of the difference in the acquisition of new technology across size classes.

However, there seems to be reason to believe that there is a systematic bias in the measure having to do with the time restriction of the measure, i.e. that it is restricted to measuring the occurrence of technology acquisition in the course of one single year. Given this time limitation, there is reason to believe that this kind of mere occurrence measure is biased in favour of the large firms, i.e. that among equally innovative firms, the measure will tend make the large firms appear more innovative than the small firms.

Consider the following argument. Let us imagine a number of firms, some small and some large, who by assumption are equally innovative when it comes to the acquisition of new technology. Let us further assume that there is a certain cycle of renewal the technology and that this cycle is substantially longer than one year. Over this cycle, all of the firms have by assumption renewed their technology to the same extent. Now, it does not seem unreasonable to suppose that if we limit our attention to one single year of this cycle, the chances that a large firm should have at least one occurrence of new technology acquisition are greater than the chances that a small firm should. If the firm is very large, the chances would seem to be great that some aspect of the firm's total activity was changed in that particular year, while a small firm might renew its technology maybe only once or twice in the course of the cycle. If this was the case, each instance of the reporting of acquisition of new technology would tend to affect a more important part of the total activity the firm in the case of small firms than in the case of large firms. Now this, if we could measure it, would represent a bias in the *opposite* direction, as by assumption all the firms renew their technology to the same extent in the course of the time which the cycle of renewal takes.

We have no way of finding out to what extent this bias in the measure is present, if present at all. It seems reasonable to expect the bias first and foremost in the case of the share of the firms who report having acquired new technology among the firms who report innovation activity and in the case of the average number of ways reported among the firms who report acquisition of new technology. Here there effectively is question of the mere occurrence of different possibilities (different possible ways of acquiring new technology) in the course of one single year.

On the other hand, this bias would not be expected to be present to the same extent in the case of the share of firms with innovation activity among all firms. Here the firms are not only asked if they have developed or introduced any technologically changed or new products or processes during the preceding *three* years (instead of one year), they are also asked whether they intend to develop or introduce any technologically changed or new products or processes during the *coming* three years. It is enough to answer 'yes' to one of these questions to be counted as having innovation activity. Clearly, here the postulated bias due to the restricted time period of the measure is far less likely to be present.

In conclusion, there seems to be a very clear tendency for the share of the firms who have acquired new technology to increase with increasing firm size. However, to a certain extent there is probably a bias inherent in the measure used, connected to the limited time period of the measure, which makes the large firms appear more innovative than the small firms, everything else equal.

7.What forms of technology acquisition are important for SMEs?

Let us now turn to the second stage of our analysis of our analysis of firm size and acquisition of new technology. In the first stage we showed that the occurrence of technology acquisition increases consistently and substantially with firm size, and also the number of ways of technology acquisition among those who have acquired new technology increases with firm size. Thus, the level of or incidence of technology acquisition increases with firm size.

In the second stage of the analysis we take the difference of the level of technology acquisition as given and focus on whether there are differences across size categories in the relative importance of different ways of acquiring new technology.

Let us first look at the relative importance of the different ways of acquiring new technology irrespective of firm size. This is shown in Table 7, below.

Table 7. **Number of firms who have acquired new technology in different ways. Share of these firms (per cent) among all firms, among firms who report innovation activity, and among firms who report acquisition of new technology in any of the ways**.

			Share, per cent		
		Number who have acquired new technology in different ways	of all firms (N=954)	of innovative firms (N=441)	of firms who have acquired new technology (N=302)
	have acquired new technology	302	31.7	68.5	100.0
e	purchase of equipment	217	22.7	49.2	71.9
c	consultancy services	139	14.6	31.5	46.0
f	information from other companies	93	9.7	21.1	30.8
a	right to use others' innovations	92	9.6	20.9	30.5
g	hiring skilled employees	75	7.9	17.0	24.8
b	R&D contracted out	55	5.8	12.5	18.2
d	purchase of other companies	33	3.5	7.5	10.9
h	other	9	0.9	2.0	3.0

Here we have shown the number of firms who have acquired new technology in different ways. The different ways are ranked according to the number of firms citing each, in descending order. First in the list is the number of firms who have acquired new technology in any of the ways, which is 302. The way of acquisition most frequently reported is 'purchase of equipment', by 217 firms, then comes ‘consultancy services’, by 139 firms. Only 9 firms have reported the residual category ‘other ways’.

Next these frequencies are shown as shares in per cent of, respectively, all firms (N=954), the firms who report innovation activity (N=441) and the firms who have acquired new technology through any of the ways (N=302). 31.7 per cent of all firms have acquired new technology. 22.7 per cent of all firms have acquired new technology through purchase of equipment, and this represents 71.9 per cent of the firms who report acquisition of new technology. 14.6 per cent of all firms have acquired new technology through consultancy services, and this represents 46 per cent of the firms who report acquisition of new technology, and so on.

We said above that we wanted to see if there are differences among size categories in the relative *importance* of the different ways of technology acquisition. We should be careful to qualify what this means. We only have data on the mere occurrence of technology acquisition through each of the ways in the course of one year. In one case, the reporting of acquisition of new technology through way A may represent a rather minor change of production processes, while in another case, the reporting of acquisition of new technology through way A may represent a number of substantial new acquisitions which as a whole amount to major changes of the firm’s activities. Similarly, in one case, the reporting of acquisition of new technology through way B may represent a rather minor change of production processes, while in another case, the reporting of acquisition of new technology through way B may represent a number of substantial new acquisitions which as a whole amount to major changes of the firm’s activities. In other words, there will be variation from case to case as to how important changes each instance of reporting of technology acquisition represents.

There may also be *systematic* variation here, so that, for instance, there is a tendency for each instance of the reporting of technology acquisition through way A to represent more important or extensive changes than each instance of the reporting of technology acquisition through way B.

There is also a possibility that systematic variation of this kind *itself* varies systematically *across* size classes. This would be the case if, for instance, in size category 1 there were a tendency for each instance of the reporting of technology acquisition through way A to represent more important or extensive changes than each instance of the reporting of technology acquisition through way B, while in size category 2 the opposite were the case, namely that there were a tendency for each instance of the reporting of technology acquisition through way *B* to represent more important or extensive changes than each instance of the reporting of technology acquisition through way A. If this were the case, it would be very problematic indeed, and the results of the present analysis might be quite misleading. However, we have no specific reasons for assuming that there should be significant *interaction* effects of this type present.

Thus, when we say that we will examine whether there are differences among size categories in the relative importance of the different ways of technology acquisition, we mean by this whether there are differences in the relative frequency distributions of the ways of technology acquisition across size categories. But we also expect this to reflect differences in the relative importance of different ways of technology acquisition across size categories.

For the remainder of this section we will limit our attention to the 302 firms who report acquisition of new technology, the aim being to investigate whether there are differences in the relative share of the different ways of technology acquisition across size categories.

In Table 8, below, we show the number of firms in each size category who report that they have acquired new technology in each of the different ways

Table 8. **Number of firms who have acquired new technology in each of the different ways, by size category**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	11	16	12	28	25	92
b	R&D contracted out	6	6	13	12	18	55
c	consultancy services	16	26	27	42	28	139
d	purchase of other companies	2	7	6	8	10	33
e	purchase of equipment	37	42	37	64	37	217
f	information from other companies	13	14	12	29	25	93
g	hiring skilled employees	7	12	13	23	20	75
h	other	3	0	3	1	2	9
	Sum	95	123	123	207	165	713
	N	56	54	54	81	57	302
	Number of ways per firm (sum/N)	1.7	2.3	2.3	2.6	2.9	2.4

As we see, from the 302 firms there are altogether 713 reports of occurrences of technology acquisition in different ways, which means an average of 2.4 per firm. To make sense of the frequencies inside the table, these should be normalized to relative frequencies. We will do this in two different ways, both as a proportion to the number of firms in each size category and as a proportion to the number of instances of the reporting of acquisition of new technology in different ways. Let us look at the frequencies as a proportion of the number of firms first. This is shown in Table 9, below.

Table 9. **Share of the firms in each size category who have acquired new technology in each of the different ways, per cent**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	19.6	29.6	22.2	34.6	43.9	30.5
b	R&D contracted out	10.7	11.1	24.1	14.8	31.6	18.2
c	consultancy services	28.6	48.1	50.0	51.9	49.1	46.0
d	purchase of other companies	3.6	13.0	11.1	9.9	17.5	10.9
e	purchase of equipment	66.1	77.8	68.5	79.0	64.9	71.9
f	information from other companies	23.2	25.9	22.2	35.8	43.9	30.8
g	hiring skilled employees	12.5	22.2	24.1	28.4	35.1	24.8
h	other	5.4	0.0	5.6	1.2	3.5	3.0
	Sum	169.6	227.8	227.8	255.6	289.5	236.1

As we see, the sum of these shares for each size category equals the average number of ways reported per firm in each size category multiplied by 100 (since the shares are in per cent). In this table, the *firms* are the units of analysis. In the columns of the table we find the five different values of the firm size variable. The eight rows of the table, however, represent eight different variables. These eight variables are all dichotomous, taking the values 1 (‘have acquired new technology in this way’) and 0 (‘have not acquired new technology in this way’), and only the share of the firms with the value 1 are shown in the table. The table is thus a compressed expression of eight different contingency tables which show the relationship between the five value firm size variable and each of the dichotomous acquisition of new technology variables. For instance, for variable a, ‘right to use others' innovations’, we have, for the under 20 employees size class, 19.6 per cent of the firms with the value 1 and accordingly 80.4 per cent with the value 0, the sum being 100, and so on for all the other size classes and for all the dichotomous acquisition of new technology variables.

We see that for all the size classes ‘purchase of equipment’ is the most frequently cited way of acquisition, and ‘consultancy services’ is invariably in second place. Only for one way of acquisition, ‘hiring of skilled employees’, the share increases invariably with firm size category, in line with the increase of average number of ways per firm cited. We may also note that for ‘purchase of equipment’ 300 or more employees category actually has the smallest share of all. However, the shares are difficult to compare across size classes in this form.

Let us turn to expressing the frequencies inside the table as a proportion to the total number of instances of the reporting of acquisition of new technology in different ways inside each size category. The relative frequencies defined in this way are shown in Table 10, below.

Table 10. **Share of total instances of reports of technology acquisition accounted for by each way of technology acquisition, by size class**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	11.6	13.0	9.8	13.5	15.2	12.9
b	R&D contracted out	6.3	4.9	10.6	5.8	10.9	7.7
c	consultancy services	16.8	21.1	22.0	20.3	17.0	19.5
d	purchase of other companies	2.1	5.7	4.9	3.9	6.1	4.6
e	purchase of equipment	38.9	34.1	30.1	30.9	22.4	30.4
f	information from other companies	13.7	11.4	9.8	14.0	15.2	13.0
g	hiring skilled employees	7.4	9.8	10.6	11.1	12.1	10.5
h	other	3.2	0.0	2.4	0.5	1.2	1.3
	Sum	100	100	100	100	100	100

This table is quite different from Table 9, above. Here the units of analysis are each instance of reporting ways of technology acquisition. Moreover, now we have only two variables. As previously, in the columns we have the firm size variable, with five values. In the rows, however, we now have the nominal variable 'way of technology acquisition', which has eight values.

We see that 'purchase of equipment' as a whole has 30.4 per cent of all instances of reports of new technology, 'consultancy services' has 19.5 per cent.

Let us see if we can say anything about differences across size categories in the shares of the different ways of technology acquisition. For instance, take 'purchase of equipment', where the total share, among all size categories, is 30.4 per cent. Here there appears to be a decline in the importance of this channel as we increase firm size. This way of technology acquisition has 38.9 per cent of the instances in the less than 20 employees category but only 22.4 per cent in the 300 or more employees category, with the middle categories falling in-between. With one rather minor exception (the 100-299 category) the trend appears to be linear. A linear trend in the opposite direction we appear to have in the case of 'hiring skilled employees', which accounts for 7.4 per cent of the instances among the firms with less than 20 employees, a share which rises steadily with firm size to reach 12.1 per cent among the firms with 300 or more employees.

However, a little reflection shows these comparisons to be misleading. For instance, we saw that 'purchase of equipment' accounted for 38.9 per cent of the instances in the less than 20 employees category but only 22.4 per cent of the instances in the 300 or more employees category. However, let us look again at the figures in Table 8, above. We see that in the 300 or more employees category there are altogether 165 instances among the 57 firms. 37 firms have reported 'purchase of equipment', which gives 22.4 per cent of the instances. Now, given total number of instances, even if *all* the 57 firms in the 300 or more employees category had reported 'purchase of equipment', this channel would only have accounted for 34.5 per cent of the instances in this size category. This would still be less than the 38.9 per cent we actually observe in the less than 20 employees category. Clearly, it would be quite misleading to say in this case that this channel was relatively more important in the less than 20 employees category than in the 300 or more employees category, when this channel by assumption is maximally important in the latter category but not in the former, where only 66.1 per cent of the firms report this channel (Table 9, above).

Obviously, the scores are not allowed to vary freely here. The distributions are constrained. No channel of technology acquisition can have 100 per cent of the instances in any size category, and the maximum share will be lower the higher the average number of ways reported per firm is. For the less than 20 employees the maximum share is 58.9 per cent (100/1.7), for the 300 or more employees category, as we have seen, 38.9 per cent (100/2.9).

To investigate this more thoroughly, let us start by looking at one particular distribution which is not constrained in this way, namely the share of the firms inside each size category who report technology acquisition through each of the ways specified *among the firms who report one way of technology acquisition only*. This distribution, or rather these distributions, are shown in Table 11, below.

Table 11. **Share of the firms, per cent, inside each size category who report technology acquisition through each of the ways specified among the firms who report one way of technology acquisition only**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	9.1	6.7	7.1	10.5	23.1	10.6
b	R&D contracted out	0.0	0.0	14.3	5.3	7.7	4.3
c	consultancy services	15.2	13.3	7.1	10.5	15.4	12.8
d	purchase of other companies	0.0	6.7	0.0	5.3	0.0	2.1
e	purchase of equipment	57.6	66.7	50.0	63.2	38.5	56.4
f	information from other companies	9.1	6.7	14.3	5.3	15.4	9.6
g	hiring skilled employees	3.0	0.0	7.1	0.0	0.0	2.1
h	other	6.1	0.0	0.0	0.0	0.0	2.1
	Sum	100	100	100	100	100	100
	N	33	15	14	19	13	94

We see that 94 of the 302 firms report one way of technology acquisition only.

Furthermore, we get an impression that the constraint concerning the share of total number of instances accounted for by 'purchase of equipment' is a real one, not just a theoretical one. We see that among the firms who report only one way of technology acquisition, 'purchase of equipment' accounts for 56.4 per cent of the instances (and the firms, which in this special case becomes the same). Now, even supposing that 'purchase of equipment' is equally dominant as a way of technology acquisition among the firms who have reported more than one way of technology acquisition, it is clear that among the firms who report two ways of technology acquisition the maximum share 'purchase of equipment' can have is 50 per cent, among those who report three ways the maximum becomes 33.3 per cent, and so on. Thus, there seems to be a clear possibility that the tendency for the share of the instances accounted for by 'purchase of equipment' to decrease with increasing firm size could be accounted for by a tendency for the share of firms who report few ways of technology acquisition, where accordingly the maximum share of the instances that 'purchase of equipment' can have is high, to decrease with firm size.

Looking at the differences across size categories among the firms who only report one way of technology acquisition (Table 11), we do not find any clear tendency for the share of the firms who report 'purchase of equipment' to decrease with firm size. Two of the other size categories have a higher share than the less than 20 employees category, but we do find that the 300 or more employees has a share which is substantially below the total. However, these differences are not statistically significant. When we reduce the number of categories of the ways of technology acquisition variable to two by keeping the 'purchase of equipment' category and combining the other seven categories in one residual category, we get a 5 x 2 contingency table. Here we get a chi square of 2.948, which with four degrees of freedom gives a probability of 0.57. The difference between the 38.5 per cent of the 300 or more employees category and the 56.4 per cent of the total may appear large, but it is not based on very many cases. The frequency expected here given an assumption of statistical independence is 7.3 (13 x 0.564), while the observed frequency is 5.

Let us now look at the exact distribution of the firms inside each category according to the number of ways of technology acquisition that they report. This is shown in Table 12, below.

Table 12. **Distribution of the firms according to number of ways of technology acquisition reported, by size category**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
Number	1	33	15	14	19	13	94
of	2	12	20	22	26	17	97
ways	3	6	11	9	18	8	52
of	4	5	5	7	9	9	35
technology	5	0	3	2	8	5	18
acquisition	6	0	0	0	1	2	3
reported	7	0	0	0	0	3	3
	sum	56	54	54	81	57	302

In Table 13, below, we show the relative frequencies, in per cent.

Table 13. **Distribution of the firms according to number of ways of technology acquisition reported, by size category. Relative frequencies, per cent**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
Number	1	58.9	27.8	25.9	23.5	22.8	31.1
of	2	21.4	37.0	40.7	32.1	29.8	32.1
ways	3	10.7	20.4	16.7	22.2	14.0	17.2
of	4	8.9	9.3	13.0	11.1	15.8	11.6
technology	5	0.0	5.6	3.7	9.9	8.8	6.0
acquisition	6	0.0	0.0	0.0	1.2	3.5	1.0
reported	7	0.0	0.0	0.0	0.0	5.3	1.0
	sum	100	100	100	100	100	100

Finally, in Table 14, below, we show the *cumulated* relative frequencies, in per cent, when the firms are ranked in ascending order on the *number of ways reported* variable.

Table 14. **Distribution of the firms according to number of ways of technology acquisition reported, by size category. Cumulated relative frequencies, per cent**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
Number	1	58.9	27.8	25.9	23.5	22.8	31.1
of	2	80.4	64.8	66.7	55.6	52.6	63.2
ways	3	91.1	85.2	83.3	77.8	66.7	80.5
of	4	100	94.4	96.3	88.9	82.5	92.1
technology	5	100	100	100	98.8	91.2	98.0
acquisition	6	100	100	100	100	94.7	99.0
reported	7	100	100	100	100	100	100

These tables confirm and show in more detail the information contained in the average number of ways figures of each size class already reported. We see that there is considerable variation across size categories in the distribution of the firms according to number of ways reported. Among the firms with less than 20 employees 58.9 per cent report only one way, while the corresponding figure for the 300 or more employees size class is only 22.8 per cent. Similarly, 91.1 per cent of the firms with less than 20 employees report three ways or less, while the corresponding figure for the firms with 300 or more employees is 66.7 per cent.

Evidently, then, when comparing the relative importance of different ways of technology acquisition across size categories we have to control explicitly for number of ways reported. We now turn to this task.

First, let us express the share of the firms in each size category who have acquired new technology in each of the different ways, reported in Table 9, above, as the difference from the corresponding share for the total. This is shown in Table 15, below.

Table 15. **Share of the firms in each size category who have acquired new technology in each of the different ways, per cent, difference from total**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	-10.8	-0.8	-8.2	4.1	13.4	0
b	R&D contracted out	-7.5	-7.1	5.9	-3.4	13.4	0
c	consultancy services	-17.5	2.1	4.0	5.8	3.1	0
d	purchase of other companies	-7.4	2.0	0.2	-1.1	6.6	0
e	purchase of equipment	-5.8	5.9	-3.3	7.2	-6.9	0
f	information from other companies	-7.6	-4.9	-8.6	5.0	13.1	0
g	hiring skilled employees	-12.3	-2.6	-0.8	3.6	10.3	0
h	other	2.4	-3.0	2.6	-1.7	0.5	0
	Sum	-66.4	-8.3	-8.3	19.5	53.4	0

In this table, as in Table 9, above, each row, each way of technology acquisition, represents one dichotomous variable, where only the differences from the total in the share of the firms who have one of the values, namely 1 as opposed to 0, 'yes' as opposed to 'no', are shown.

We see that the less than 20 employees has a lower share than the total on all the ways of technology acquisition apart from the residual category 'other', while on the opposite side the 300 or more employees category has a higher share than the total on all the ways of technology acquisition apart from 'purchase of equipment'. For each size category the sum of the eight differences equals the difference from the total in the average number of ways of technology acquisition reported per firm, multiplied by 100.

To control for the effect of variation across size categories in the number of ways of technology acquisition per firm, we will now compute the difference between the share of the firms in each size category who have acquired new technology in each of the ways and the corresponding share for all size categories as a whole *for each value of the number of ways of technology acquisition variable separately*.

Let us start with the firms who report only one way of technology acquisition. The shares are given in Table 11, above. In Table 16, below, we show for each size category the difference between its shares for each of the ways of technology acquisition and the shares for all size categories combined among those firms who report one way of technology acquisition only.

Table 16. **Share of the firms in each size category who have acquired new technology in each of the different ways, per cent, difference from total. Firms who report one way of technology acquisition only**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	-1.5	-4.0	-3.5	-0.1	12.4	0
b	R&D contracted out	-4.3	-4.3	10.0	1.0	3.4	0
c	consultancy services	2.4	0.6	-5.6	-2.2	2.6	0
d	purchase of other companies	-2.1	4.5	-2.1	3.1	-2.1	0
e	purchase of equipment	1.2	10.3	-6.4	6.8	-17.9	0
f	information from other companies	-0.5	-2.9	4.7	-4.3	5.8	0
g	hiring skilled employees	0.9	-2.1	5.0	-2.1	-2.1	0
h	other	3.9	-2.1	-2.1	-2.1	-2.1	0
	Sum	0	0	0	0	0	0

Since these are only the firms who report one way of technology acquisition, the shares for each size category over all eight ways of technology acquisition sum to 100, and consequently the sum of the differences from the total equals 0.

We now turn to the firms who report two ways of technology acquisition. The shares of the firms in each size category who report having acquired new technology in each of the ways specified for this class of firms are given in Table 17, below.

Table 17. **Share of the firms, per cent, inside each size category who report technology acquisition through each of the ways specified among the firms who report two ways of technology acquisition only**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	25.0	35.0	13.6	34.6	5.9	23.7
b	R&D contracted out	16.7	5.0	18.2	3.8	17.6	11.3
c	consultancy services	50.0	50.0	54.5	50.0	41.2	49.5
d	purchase of other companies	0.0	10.0	9.1	0.0	5.9	5.2
e	purchase of equipment	66.7	70.0	63.6	76.9	64.7	69.1
f	information from other companies	16.7	20.0	13.6	19.2	35.3	20.6
g	hiring skilled employees	16.7	10.0	27.3	11.5	23.5	17.5
h	other	8.3	0.0	0.0	3.8	5.9	3.1
	Sum	200	200	200	200	200	200
	N	12	20	22	26	17	97

We see that altogether 97 firms report two ways of technology acquisition. Since all report two ways, the sum of the shares over all eight ways of acquisition necessarily equals 200 per cent for all size categories.

We now turn to expressing these shares as the difference from the share of all firms who report two ways of technology acquisition. These differences are shown in Table 18, below.

Table 18. **Share of the firms in each size category who have acquired new technology in each of the different ways, per cent, difference from total. Firms who report two ways of technology acquisition only**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	1.3	11.3	-10.1	10.9	-17.8	0
b	R&D contracted out	5.3	-6.3	6.8	-7.5	6.3	0
c	consultancy services	0.5	0.5	5.1	0.5	-8.3	0
d	purchase of other companies	-5.2	4.8	3.9	-5.2	0.7	0
e	purchase of equipment	-2.4	0.9	-5.4	7.9	-4.4	0
f	information from other companies	-4.0	-0.6	-7.0	-1.4	14.7	0
g	hiring skilled employees	-0.9	-7.5	9.7	-6.0	6.0	0
h	other	5.2	-3.1	-3.1	0.8	2.8	0
	Sum	0	0	0	0	0	0

Again, the sum of the differences for each size category is 0.

In this way, we proceed with the firms who have reported three ways of technology acquisition, then four, five, six and lastly seven ways. I will not present the shares and the percentage points differences for these here, though.

For each way of technology acquisition we thus get for each size class a percentage points difference for each value of the number of ways variable. In the case of less than 20 employees category we get four such differences, then for the next two size categories we get five, for the 100-299 employees categories we get six differences, and lastly, for the 300 or more employees category, seven such differences (cf. Table 12, above). The last difference for latter category is a special case, as only in this size category there are firms who report seven different ways. Consequently, there is no-one to compare with in this case, and the difference must be 0.

Now, how can we get from these four to seven differences (depending on the size class) to one single expression of the relative importance of the different ways of technology acquisition for each size class? The way I have done this is the following.

The point is to compare the different size classes when it comes to the relative importance of each way of technology acquisition. Each way of technology acquisition is thus considered separately. Thus, we start with one way of technology acquisition, then go on to the next, etc.

For each way of technology acquisition, we then take one size class at a time. For each size category we compute a weighted average, across all values of the number of ways of technology acquisition variable, of the percentage difference between the share of the firms in *this size class* and the share of the firms in *all size classes combined* who have reported this way of technology acquisition. The *weights* for each size category are defined as the share of all firms in the size category accounted for by each value of the number of ways of acquisition variable, reported in Table 13, above.

For any way of technology acquisition, the adjusted percentage difference, *ADP*, of size class k becomes

$$APD_k = \sum_i (p_{ik} - p_{it}) \cdot \frac{n_{ik}}{n_k}$$

where i is the number of ways of technology acquisition reported, p_{ik} is the share of the firms in the k size category who report i ways of technology acquisition accounted for by firms who report the way of technology acquisition in question, p_{it} is the share of the firms in *all* size categories who report i ways of technology acquisition accounted for by firms who report the way of technology acquisition in question, n_{ik} is the number of firms in the k size category who report i ways of technology acquisition and n_k is the number of all firms in the k size category.

To take one example, consider the first way of technology acquisition, 'right to use others' innovations', and size category 1, with less than 20 employees. From Table 13, above, it emerges that 58.9 per cent of the firms in the less than 20 employees category report one way of technology acquisition, 21.4 per cent report two ways, 10.7 per cent report three ways and 8.9 per cent report four ways. No firms in this size class report more than four ways. The weights thus become, respectively, 0.589, 0.214, 0.107 and 0.089.

Above we saw that among the firms who report one way of technology acquisition, the percentage point difference between the share of the firms in the less than 20 employees category and the share of the firms in all size categories together who report 'right to use others' innovations' is - 1.5 (Table 16). The corresponding percentage points difference among the firms who report two ways of technology acquisition we saw was 1.3 (Table 18). Likewise, not shown above, the corresponding difference for the firms who report three ways is - 1.3 and for those who report four ways - 2.9. Thus, the adjusted percentage points difference for the less than 20 employees size category for 'right to use others' innovations' becomes

$$(-1.5 \bullet .589) + (1.3 \bullet 0.214) + (-1.3 \bullet 0.107) + (-2.9 \bullet 0.089) = -1.0.$$

In the same way we proceed with all eight ways of technology acquisition and all five size classes. The results are shown in Table 19, below.

Table 19. **Difference, percentage points, between the share of the firms in each size class and the share of the firms in all size classes as a whole who report each way of technology acquisition, adjusted for differences in number of ways of technology acquisition reported. Results obtained by summing weighted percentage differences**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	-1.0	1.0	-6.8	1.4	4.5	0
b	R&D contracted out	0.6	-5.7	8.3	-6.0	5.4	0
c	consultancy services	-2.2	2.0	3.9	1.0	-4.9	0
d	purchase of other companies	-2.6	4.1	1.8	-1.5	-0.8	0
e	purchase of equipment	0.9	5.8	-3.4	4.9	-10.1	0
f	information from other companies	2.9	-3.2	-7.0	1.7	4.4	0
g	hiring skilled employees	-1.3	-0.9	0.7	0.4	0.9	0
h	other	2.8	-3.1	2.5	-2.0	0.6	0
	Sum	0	0	0	0	0	0

By adding (respectively, subtracting) these differences to (respectively, from) the totals for each way of acquisition (reported in the 'total' column in Table 9, above), we get the following figures for the *adjusted* share of the firms who report each way of technology acquisition in each size category, i.e. adjusted for differences in number of ways of technology acquisition reported. These adjusted shares are shown in Table 20, below.

Table 20. **Share of the firms inside each size category who have acquired new technology in each of the different ways, adjusted for differences in number of ways reported. Results obtained by summing weighted percentage differences**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	29.4	31.5	23.7	31.9	34.9	30.5
b	R&D contracted out	18.9	12.6	26.5	12.2	23.6	18.2
c	consultancy services	43.8	48.0	50.0	47.0	41.1	46.0
d	purchase of other companies	8.3	15.0	12.7	9.5	10.1	10.9
e	purchase of equipment	72.7	77.6	68.4	76.8	61.8	71.9
f	information from other companies	33.7	27.6	23.7	32.5	35.2	30.8
g	hiring skilled employees	23.5	23.9	25.6	25.2	25.7	24.8
h	other	5.8	-0.1	5.5	1.0	3.6	3.0
	Sum	236.1	236.1	236.1	236.1	236.1	236.1

In Table 9, above, we saw that the corresponding observed, *unadjusted* shares of the different ways of technology acquisition for each size category together sum to the average number of ways of technology acquisition reported in the size category in question (multiplied by 100). In the present table we see that the adjustments made when controlling for differences in the number of ways reported amount to letting the average number of ways of technology acquisition be the same in each size category, and equal to the average number of ways actually reported for all firms as a whole.

However, let us try to improve on the quality of the above analysis by using a somewhat more rigorous approach. The basic idea of controlling for differences in number of ways reported will be the same as explained above, but I will now use regression analysis with dummy variables to estimate the adjusted percentage differences and shares.

The firm size variable is here treated as nominal, with five categories. This variable has thus been transformed into four (5-1) dummy variables, using the less than 20 employees category as reference group. Similarly, the number of ways reported variable has also been treated as a nominal variable, with seven categories, and has consequently been transformed into six (7-1) dummy variables. The regression coefficients for the firm size dummy variables when controlling for number of ways reported are shown in Table 21, below.

Table 21. **Regression coefficients, size category variables, when the five categories firm size variable has been transformed into four dummy variables, using the less than 20 employees category as reference group, controlling for number of ways of technology acquisition reported, also transformed into dummy variables**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total (weighted average)
a	right to use others' innovations	0	0.022	-0.056	0.027	0.061	0.013
b	R&D contracted out	0	-0.065	0.076	-0.069	0.050	-0.007
c	consultancy services	0	0.045	0.064	0.034	-0.029	0.023
d	purchase of other companies	0	0.069	0.046	0.014	0.019	0.028
e	purchase of equipment	0	0.049	-0.044	0.040	-0.119	-0.011
f	information from other companies	0	-0.063	-0.102	-0.013	0.017	-0.030
g	hiring skilled employees	0	0.006	0.022	0.019	0.024	0.015
h	other	0	-0.062	-0.005	-0.051	-0.025	-0.030
	Sum	0	0	0	0	0	0

Taking way of technology acquisition *a*, 'right to use others' innovations' as an example, we see that when we control for number of ways reported the share of the 20-49 employees category is 0.022 or 2.2 per cent *higher* than the share of the less than 20 employees category, the share of the 50-99 employees category is 0.056 or 5.6 per cent *lower* than the share of the less than 20 employees category, etc.

The *total* in Table 21 is simply the weighted average of the regression coefficients for the size classes, *including* the by definition zero coefficient of the less than 20 employees category. The *weights* are defined by the share of the total number of firms accounted for by each size class.

Now, to get figures which are equivalent to the adjusted percentage differences presented in Table 19, above, we simply take the regression coefficients of each of the size classes in Table 21 and *subtract* from these the weighted average figure for the total. For the less than 20 employees category this means subtracting this total from 0, and thus the less than 20 employees size class just get the total figure of Table 21 with the opposite sign. To express all differences in percentage points, we multiply all figures by 100. The results are shown in Table 22, below.

Table 22. **Difference, percentage points, between the share of the firms in each size class and the share of the firms in all size classes as a whole who report each way of technology acquisition, adjusted for differences in number of ways of technology acquisition reported. Results obtained by means of regression analysis with dummy variables**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	-1.3	0.9	-6.9	1.5	4.9	0
b	R&D contracted out	0.7	-5.8	8.3	-6.2	5.7	0
c	consultancy services	-2.3	2.2	4.1	1.1	-5.2	0
d	purchase of other companies	-2.8	4.1	1.8	-1.4	-0.9	0
e	purchase of equipment	1.1	6.0	-3.3	5.1	-10.8	0
f	information from other companies	3.0	-3.3	-7.2	1.7	4.7	0
g	hiring skilled employees	-1.5	-0.9	0.7	0.4	1.0	0
h	other	3.0	-3.1	2.5	-2.1	0.6	0
	Sum	0	0	0	0	0	0

When we compare these results obtained by means of regression analysis to the corresponding results presented in Table 19, above, obtained by the more intuitive method of summing weighted percentage points differences, we find that the figures are very similar.

We should point out that the results obtained here are not dependent upon using the less than 20 employees category as the reference group. The results are the same, of course, irrespective of which size class is used as reference group when we construct the dummy variables.

In the same way as we did with the adjusted percentage differences in Table 19, above, to create the adjusted shares of Table 20, above, we can compute the share of the firms inside each size category, adjusted for differences in number of ways reported, who have acquired new technology in each of the different ways, by adding the adjusted percentage point differences in Table 22 to the actual figures for the total, reported in Table 9, above. These adjusted shares are shown in Table 23, below.

Table 23. **Share of the firms inside each size category who have acquired new technology in each of the different ways, adjusted for differences in number of ways reported. Results obtained by means of regression analysis with dummy variables**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	29.2	31.4	23.6	31.9	35.3	30.5
b	R&D contracted out	18.9	12.4	26.5	12.0	24.0	18.2
c	consultancy services	43.7	48.2	50.1	47.1	40.8	46.0
d	purchase of other companies	8.1	15.0	12.8	9.5	10.1	10.9
e	purchase of equipment	73.0	77.8	68.5	76.9	61.1	71.9
f	information from other companies	33.8	27.5	23.6	32.5	35.5	30.8
g	hiring skilled employees	23.4	23.9	25.6	25.3	25.8	24.8
h	other	6.0	-0.2	5.5	0.9	3.6	3.0
	Sum	236.1	236.1	236.1	236.1	236.1	236.1

Of course, since the results in Table 22 are very similar to those of Table 19, the results reported in Table 23 have to be very similar to those reported in Table 20. We see that also in this case the adjustment for differences in number of ways reported amounts to letting each size class have the same average number of ways reported per firm as the average for all size classes combined.

Let us use the adjusted percentage point differences and the adjusted shares obtained by means of the regression analysis and reported in Table 22 and Table 23 instead of the corresponding figures from Tables 19 and 20 hereafter.

The adjusted shares in Table 23 may also be expressed by letting the shares in each size class sum to 100, like we did with the unadjusted shares in Table 10, above. As we remember, this amounts to letting each report be the unit of analysis and each way of technology acquisition be a value of a nominal variable with eight values. However, this time the bias due to differences in the number of ways of technology acquisition is sought removed. The *adjusted* shares when summed to 100 are shown in Table 24, below.

Table 24. **Share of total instances of reports of technology acquisition accounted for by each way of technology acquisition, by size class, adjusted for differences in number of ways of technology acquisition reported. Results obtained by means of regression analysis with dummy variables**.

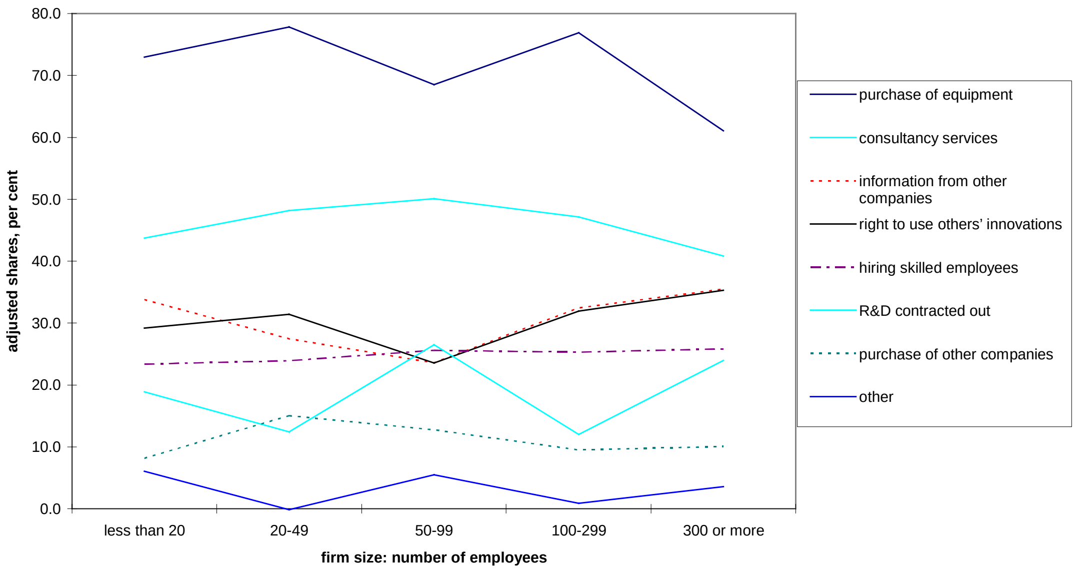
		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	12.4	13.3	10.0	13.5	15.0	12.9
b	R&D contracted out	8.0	5.3	11.2	5.1	10.1	7.7
c	consultancy services	18.5	20.4	21.2	20.0	17.3	19.5
d	purchase of other companies	3.4	6.4	5.4	4.0	4.3	4.6
e	purchase of equipment	30.9	33.0	29.0	32.6	25.9	30.4
f	information from other companies	14.3	11.6	10.0	13.7	15.0	13.0
g	hiring skilled employees	9.9	10.1	10.8	10.7	10.9	10.5
h	other	2.6	-0.1	2.3	0.4	1.5	1.3
	Sum	100	100	100	100	100	100

First, let us relate to our comments on the corresponding table for the unadjusted shares of total instances, Table 10, above. There we appeared to find a fairly clear linear relationship between firm size and the share of total instances reported accounted for by purchase of equipment: the larger the firms, the less the relative importance of purchase of equipment (with one minor anomaly). However, as we suspected, this relationship turns out *not* to hold when we control for number of ways reported. It is true that the 300 or more employees category has a share which is well below the others, but apart from this there is no clear pattern.

Let us now look more closely at the differences across size classes in the relative importance of the different ways of technology acquisition, reported in Tables 22-24, which all express these differences when we adjust for number of ways of acquisition reported. Are these differences large for any of the ways of technology acquisition? Can we make sense of them? As we shall see, the answers to these questions are by and large negative.

First, let us look briefly at Figure 1, below, where the adjusted shares reported in Table 23 are depicted graphically.

Figure 1. **Share of the firms inside each size category who have acquired new technology in each of the different ways, adjusted for differences in number of ways reported**.



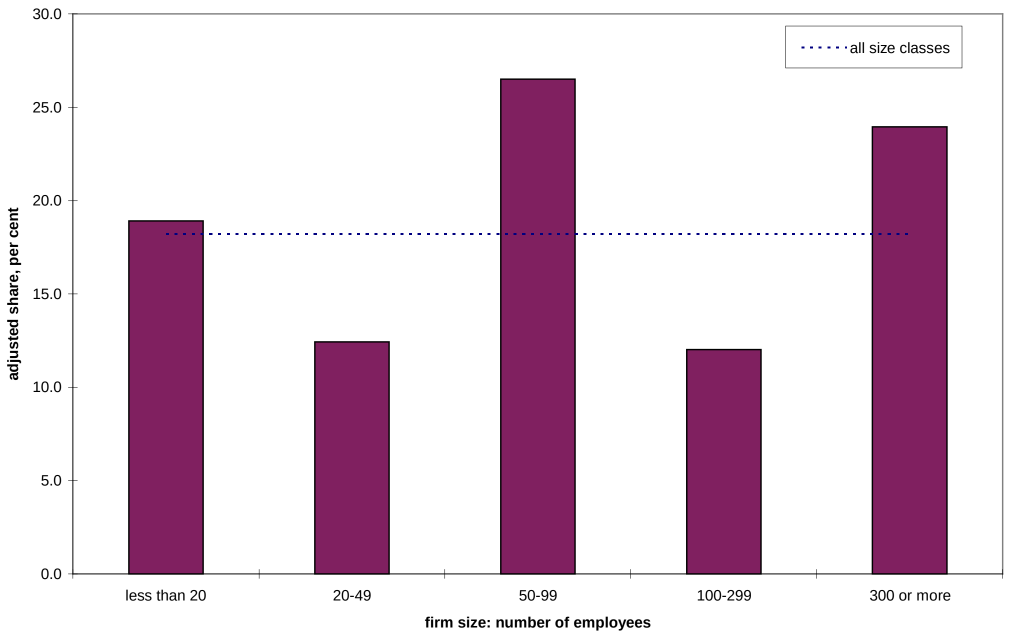
A casual inspection of Table 23 and Figure 1 does not reveal any striking patterns of differences in the relative importance of different ways of technology acquisition across size classes. Particularly, there are no cases of reversal of relative importance of two ways of technology acquisition as we go from the small to the large firms, with one way of technology acquisition being clearly more important than the other among the small firms while the opposite is the case among the large firms. On the contrary, the ranking of the ways of technology acquisition seem to be roughly the same in all size classes.

Are these adjusted differences across size classes statistically significant at all? Let us make this a question of whether the regression coefficients of the size class dummy variables are significant at the 5 per cent level, with a two-tailed test. To find out this we ran the regression analysis four times for each of the eight ways of technology acquisition, first with size class 1, with less than 20 employees, as reference group to see whether size class 1 differed significantly from any of the four other size classes, then with size class 2 as reference group to see whether size class 2 differed significantly from size class 3, 4 or 5, then with size class 3 as reference group to see whether size class 3 differed significantly from size class 4 or 5, and finally with size class 4 as reference group to see whether size class 4 differed significantly from size class 5. For each of the eight ways of technology acquisition we thus get 10 differences between size classes. Now, this kind of comparison one by one of the differences is perhaps not acceptable as a rigorous test of significance, but nevertheless we get a general idea of which differences may be significant.

When we do this, we find significant differences, at the 5 per cent significance level, for only two of the ways of technology acquisition, namely (b) *R&D contracted out*, and (e) *purchase of equipment*. For the other six ways of technology acquisition, none of the adjusted differences between size classes are significant.

Let us first look at *R&D contracted out*. The adjusted shares reported in Table 23 are shown graphically for *R&D contracted out* in Figure 2, below.

Figure 2. **Share of the firms inside each size category who have acquired new technology through R&D contracted out, adjusted for differences in number of ways reported**.

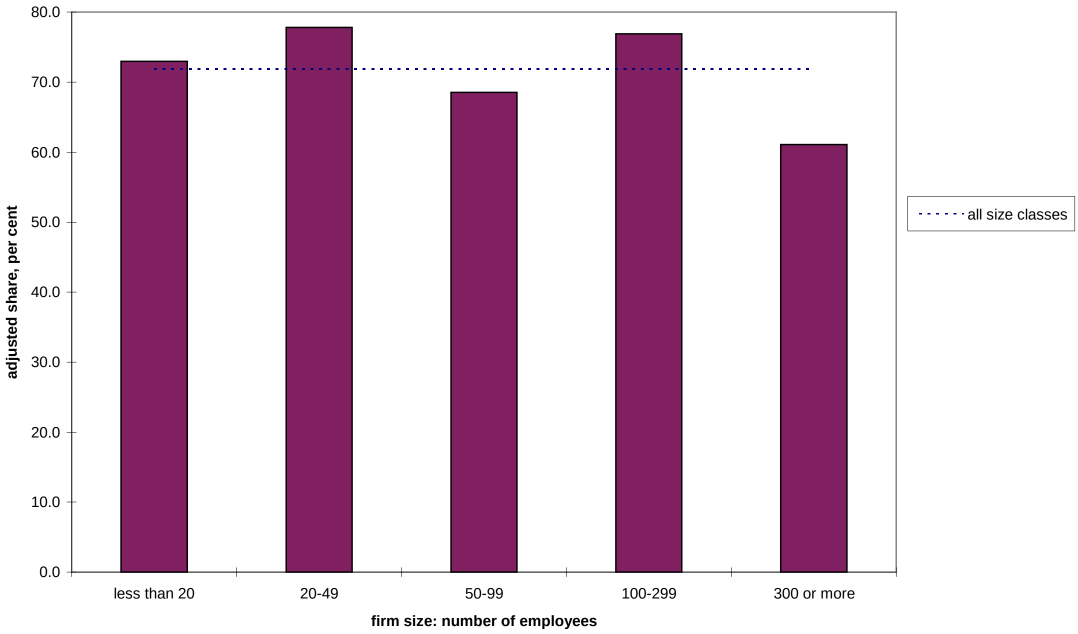


Here the 50-99 employees class has the highest share, the 300 or more class, then the less than 20 class, and some way below the (weighted) average the 20-49 class and lastly the 100-299 employees class.

Three of the ten differences between size classes are significant at the 5 per cent level here. The 50-99 employees category has a significantly higher share than both the 20-49 and the 100-299 employees category. In addition, the 300 or more employees category has a significantly higher share than the 100-299 employees category.

Let us now turn to *purchase of equipment*. Here the adjusted shares (from Table 23) are shown in Figure 3, below.

Figure 3. **Share of the firms inside each size category who have acquired new technology through purchase of equipment, adjusted for differences in number of ways reported**.



This figure almost seems like the mirror image of Figure 2. The 20-49 employees category has the highest adjusted share, followed by the 100-299 employees category, the less than 20 employees category, the 50-99 employees category and, lastly, the 300 or more employees category.

Two of the ten differences between size classes are significant at the 5 per cent level here: the 300 or more employees category has a significantly lower share than both the 20-49 employees category and the 100-299 employees category.

Thus, it appears that when we adjust for the number of ways of technology acquisition reported to assess the *relative* importance of the different ways of technology acquisition, we find very few significant differences across size classes. Furthermore, even if a couple of the differences may be statistically *significant*, this need not mean that they are large enough to be of any substantive interest. Indeed, a casual glance at Figure 1 did not reveal any striking differences across size classes.

The impression that the differences which we find across size classes here are of little or no importance is strengthened by the impression that they are very hard to make sense of. In the cases where we seem to find statistically significant differences at all, we do not find any intelligible pattern in these differences. We do not find any linear relationship where the relative importance of a way of technology acquisition consistently increases or decreases with increasing firm size. We do not even find any relationship where the shares go up and the down again or vice versa as we go from the small to the large firms. Rather, as we go from the small firms through the middle categories to the large, the shares seem to go up and down in no intelligible pattern. For instance, for 'R&D contracted out', where we found a couple of significant differences, the share is very close to the total for the less than 20 employees size class, then is some way below the total for the next, then goes some way above, then some way below, and lastly above again. Similarly, for 'purchase of equipment' we start approximately at the share of the total for the smallest firms, and then the share goes up, then down, then up, and then down again. These seemingly erratic movements strengthen our suspicion that what we are dealing with here is little more than random variation.

The conclusion so far is that we do not find any important differences across size categories concerning the relative importance of different ways of acquisition of new technology.

8. Controlling for industry

However, it would not by a wholly unreasonable hypothesis that the relative importance of the different ways of acquisition of new technology should vary across *industries*. Also, the size distribution of the firms probably varies across industries (or, alternatively, the industry distribution of the firms varies across size classes). Therefore, to analyse the effect of firm size on the relative importance of different ways of acquisition of new technology, we should also control for variation in the size composition of firms across *industries*.

We have divided the manufacturing sector into 15 different industries. Table 25, below, shows which these industries are and how the 302 manufacturing firms in the sample who report acquisition of new technology are distributed across industries and size classes.

Table 25. **Distribution of firms who have acquired new technology by industry and size class**.

	Size category: number of employees					
	under 20	20-49	50-99	100-299	300 or more	total
Food, beverage and tobacco	8	16	12	11	9	56
Textiles, clothing	2	4	0	5	0	11
Wood products	5	8	3	5	1	22
Pulp and paper	0	1	0	4	5	10
Graphical industry	11	8	7	10	4	40
Chemicals	3	0	6	4	6	19
Pharmaceuticals	1	0	1	0	2	4
Mineral products	1	3	1	5	2	12
Metals	0	0	3	4	6	13
Metal products	5	6	7	6	4	28
Machinery	4	3	4	7	9	27
Transport equipment	6	3	3	9	5	26
Electronics	5	2	3	4	2	16
Electrical machinery, etc.	4	0	2	6	2	14
Other manufacturing	1	0	2	1	0	4
total	56	54	54	81	57	302

To make the difference in 'industrial structures' across size classes come out more clearly, the frequencies in Table 25, above, are expressed as shares of the total number of firms in each size category in Table 26, below.

Table 26. **Distribution of the firms in each size class by industry, per cent (N=302)**.

	Size category: number of employees					
	under 20	20-49	50-99	100-299	300 or more	total
Food, beverage and tobacco	14.3	29.6	22.2	13.6	15.8	18.5
Textiles, clothing	3.6	7.4	0.0	6.2	0.0	3.6
Wood products	8.9	14.8	5.6	6.2	1.8	7.3
Pulp and paper	0.0	1.9	0.0	4.9	8.8	3.3
Graphical industry	19.6	14.8	13.0	12.3	7.0	13.2
Chemicals	5.4	0.0	11.1	4.9	10.5	6.3
Pharmaceuticals	1.8	0.0	1.9	0.0	3.5	1.3
Mineral products	1.8	5.6	1.9	6.2	3.5	4.0
Metals	0.0	0.0	5.6	4.9	10.5	4.3
Metal products	8.9	11.1	13.0	7.4	7.0	9.3
Machinery	7.1	5.6	7.4	8.6	15.8	8.9
Transport equipment	10.7	5.6	5.6	11.1	8.8	8.6
Electronics	8.9	3.7	5.6	4.9	3.5	5.3
Electrical machinery, etc.	7.1	0.0	3.7	7.4	3.5	4.6
Other manufacturing	1.8	0.0	3.7	1.2	0.0	1.3
Sum	100	100	100	100	100	100

Clearly, as we would expect, we find substantial variation in ‘industrial structure’ across size classes. This is the mirror image of the fact that in some industries, for instance *pulp and paper*, *metals*, *chemicals* and *electrical machinery*, the firms tend to be quite large (for instance, as measured by the median number of employees), while in other industries, for instance *textiles and clothing*, *wood products*, *metal products* and *food, beverage and tobacco*, they tend to be much smaller.

Let us now try to adjust the differences across size classes in the share of the firms who report acquisition of new technology through different ways not only for variation in the number of ways reported but also for variation in the distribution of firms across industries.

Let me first explain how the intuitive approach of calculating the weighted average of percentage differences works in this case. The basis for this is that for each value of the control variable we look at the share of the firms in each size class who have acquired new technology through the channel in question and calculate the percentage points difference between this share and the corresponding share of the firms in all size categories as a whole. Then, for each size category, we calculate the weighted sum of these differences over all values of the control variable, using the share of the firms in the size category in question accounted for by each value of the control variable as weights. However, this time we not only calculate these differences for each value of the number of ways of technology acquisition variable, but for each value of the number of ways of technology acquisition variable *inside each industry*, and weigh these differences in the same way as before. Since we have seven values of the former variable and 15 industries, this makes for a maximum of

105 such differences. However, many of the weights will be 0. For instance, since no firms in the less than 20 employees category report more than four different ways, we already know that the maximum number of differences for this size category will be 60 (15 • 4). Furthermore, as Table 12 shows, only 12 firms in this size category report two ways, only six firms report three ways and only five firms report four ways, so clearly the number of differences for this size category has to be considerably less than 60.

In the case where we only controlled for number of ways reported, above, we saw that the results obtained by way of this weighted average difference method were very similar to the results obtained through regression analysis. However, there are some special problems with using the more intuitive method of calculating weighted average percentage point differences in the case where we also control for industry, owing to the small number of firms we get in many of the categories when we classify the 302 firms, already divided into five size classes, into combinations of two control variables with, respectively, seven and fifteen values. One problem which may be serious is that for many combinations of the two control variables only one the size classes will be represented. In these cases the share for the size category is necessarily equal to the share of the total, and the difference is necessarily 0. This means that a part of the total weight of the size category in question may carry differences which are necessarily 0, and this part is not necessarily small in this case. This may have the consequence, firstly, that the resulting weighted sum of differences may be smaller than what should have been, given that the differences that actually exist, if they go consistently in one direction, will be diluted by a high share of total weight of necessarily 0 differences. Secondly, the method used here does not allow one to actually evaluate the share of one size category when there are no other size category represented in the combination of control variable values, in contradistinction to what is attempted for instance in an analysis of covariance (ANCOVA). Even in the cases where only one size category is represented in a particular combination of the number of ways and the industry variable, a linear estimation, for instance, might make it probable that the share actually observed was, for instance, much lower than what we would have expected for all size categories combined, but the method used here has no way of taking account of this but must set the difference equal to zero. Thus, not only may this method in the context of a high number of shares which cannot be compared to something else result in an attenuation of the weighted sum of differences, but more serious distortions may arise also.

For these reasons, we will not perform the adjustment analysis in its simpler, more intuitive form. Thus, we will only use the more rigorous regression analysis when we control also for industry. However, one can keep the more intuitive method in mind to get an approximate idea of what the adjustments are about.

We proceed in the same way as when we only controlled for number of ways reported above, with the difference that this time we also have to include the 15 category industry variable. This is transformed into 14 dummy variables. Thus, we have a multiple regression equation with four dummy variables to represent the five firm size classes, six dummy variables to represent the seven occurring number of ways of technology acquisition reported, and 14 dummy variables to represent the 15 industries.

In the same way as above, we get four regression coefficients for the four size class dummies, one for each. In addition, the reference group has the coefficient 0. When we take the weighted average of these five coefficients, using the share of all firms accounted for by each size class as weights, we get an expression for the total. These coefficients and weighted average totals are shown in Table 27, below, where the less than 20 employees category is used as reference group.

Table 27. **Controlling for industry. Regression coefficients, size category variables, when the five categories firm size variable has been transformed into four dummy variables, using the less than 20 employees category as reference group, controlling for number of ways of technology acquisition reported and for industry, also transformed into dummy variables**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total (weighted average)
a	right to use others' innovations	0	0.038	-0.057	0.020	0.055	0.012
b	R&D contracted out	0	-0.040	0.092	-0.050	0.048	0.005
c	consultancy services	0	0.054	0.066	0.030	-0.046	0.021
d	purchase of other companies	0	0.065	0.035	0.016	0.009	0.024
e	purchase of equipment	0	-0.034	-0.084	0.017	-0.120	-0.039
f	information from other companies	0	-0.046	-0.091	-0.026	0.012	-0.029
g	hiring skilled employees	0	0.028	0.036	0.040	0.057	0.033
h	other	0	-0.066	0.002	-0.047	-0.014	-0.027
	Sum	0	0	0	0	0	0

Again we get the adjusted percentage points differences by subtracting the weighted average of the total from each of the regression coefficients. The results of this analysis are shown in Table 28, below.

Table 28. **Controlling for industry. Difference, percentage points, between the share of the firms in each size class and the share of the firms in all size classes as a whole who report each way of technology acquisition, adjusted for differences in number of ways of technology acquisition reported and for differences in distribution across industries. Results obtained by means of regression analysis with dummy variables**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	-1.2	2.6	-6.9	0.8	4.2	0
b	R&D contracted out	-0.5	-4.5	8.7	-5.5	4.3	0
c	consultancy services	-2.1	3.4	4.5	0.9	-6.7	0
d	purchase of other companies	-2.4	4.1	1.1	-0.8	-1.5	0
e	purchase of equipment	3.9	0.5	-4.5	5.6	-8.1	0
f	information from other companies	2.9	-1.7	-6.2	0.3	4.1	0
g	hiring skilled employees	-3.3	-0.5	0.3	0.7	2.4	0
h	other	2.7	-3.9	2.8	-2.0	1.3	0
	Sum	0	0	0	0	0	0

Like we did with the adjusted percentage point differences when we only controlled for number of ways reported, here too we can get an expression of the adjusted shares of the firms inside each size category who report each of the ways of technology acquisition by adding the differences in Table 28 to the shares for the total (reported in the 'total' column in Table 9). The results are shown in Table 29, below.

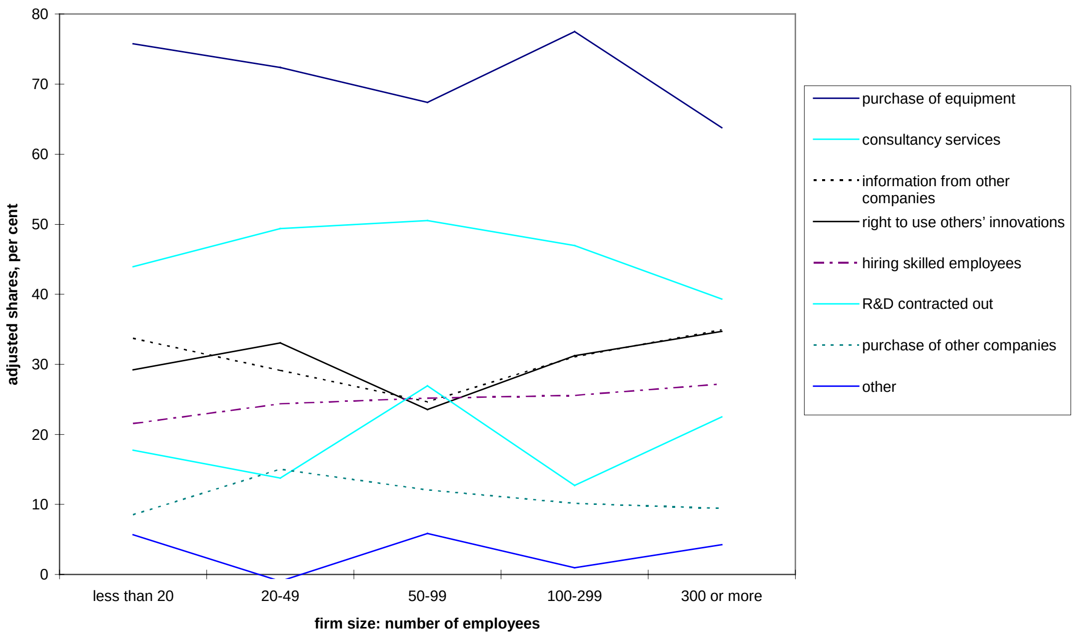
Table 29. **Controlling for industry. Share of the firms inside each size category who have acquired new technology in each of the different ways, adjusted for differences in number of ways reported and for differences in distribution across industries. Results obtained by means of regression analysis with dummy variables**.

		Size category: number of employees					
		under 20	20-49	50-99	100-299	300 or more	total
a	right to use others' innovations	29.2	33.0	23.5	31.2	34.7	30.5
b	R&D contracted out	17.7	13.8	26.9	12.7	22.5	18.2
c	consultancy services	43.9	49.4	50.5	47.0	39.3	46.0
d	purchase of other companies	8.5	15.0	12.1	10.2	9.4	10.9
e	purchase of equipment	75.8	72.4	67.4	77.5	63.8	71.9
f	information from other companies	33.7	29.1	24.6	31.1	34.9	30.8
g	hiring skilled employees	21.5	24.4	25.2	25.5	27.2	24.8
h	other	5.7	-1.0	5.8	0.9	4.3	3.0
	Sum	236.1	236.1	236.1	236.1	236.1	236.1

Again we see that the adjustments made in the course of the analysis amount to letting each size category have equal average number of ways reported per firm.

These adjusted shares are depicted graphically in Figure 4, below.

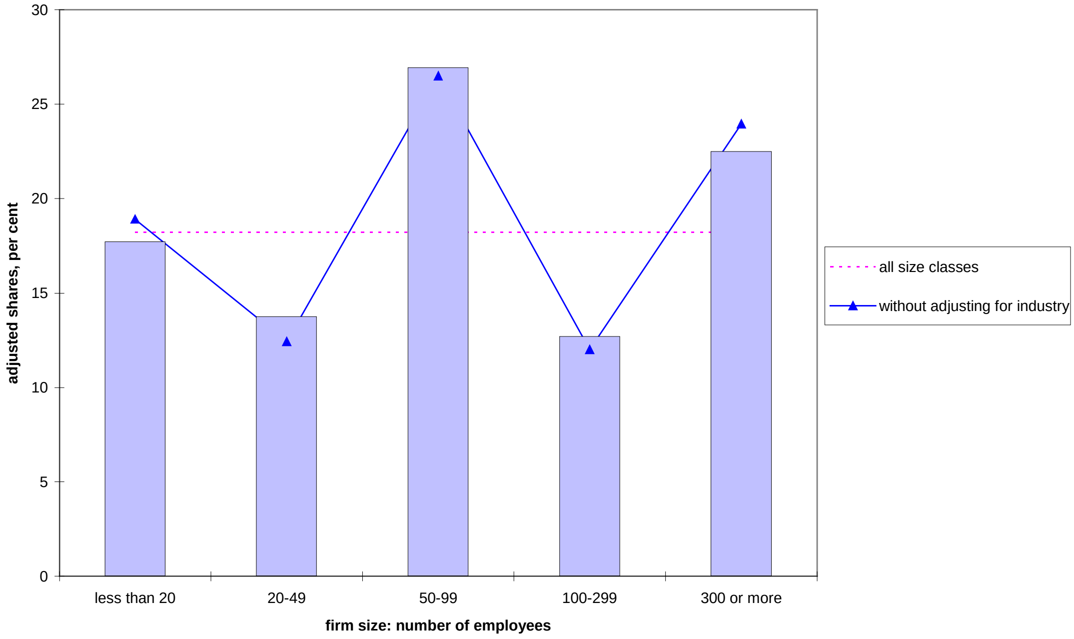
Figure 4. **Controlling for industry. Share of the firms inside each size category who have acquired new technology in each of the different ways, adjusted for differences in number of ways reported and for differences in distribution across industries**.



Looking at Figure 4 and Tables 28 and 29 we get a strong impression that controlling for industry does not in any significant way alter the conclusions from the above analysis where we only controlled for number of ways reported. Figure 4 looks very much like Figure 1. The differences across size categories are no greater, and there is still not much linearity to see.

In fact, when we control for industry in addition to number of ways reported, we find significant differences across size classes for only one of the ways of technology acquisition, namely *b*, *R&D contracted out*. In Figure 5, below, the adjusted shares for *R&D contracted out* when controlling for industry and number of ways reported are shown.

Figure 5. **Controlling for industry. Share of the firms inside each size category who have acquired new technology through R&D contracted out, adjusted for differences in number of ways reported and for differences in distribution across industries**.

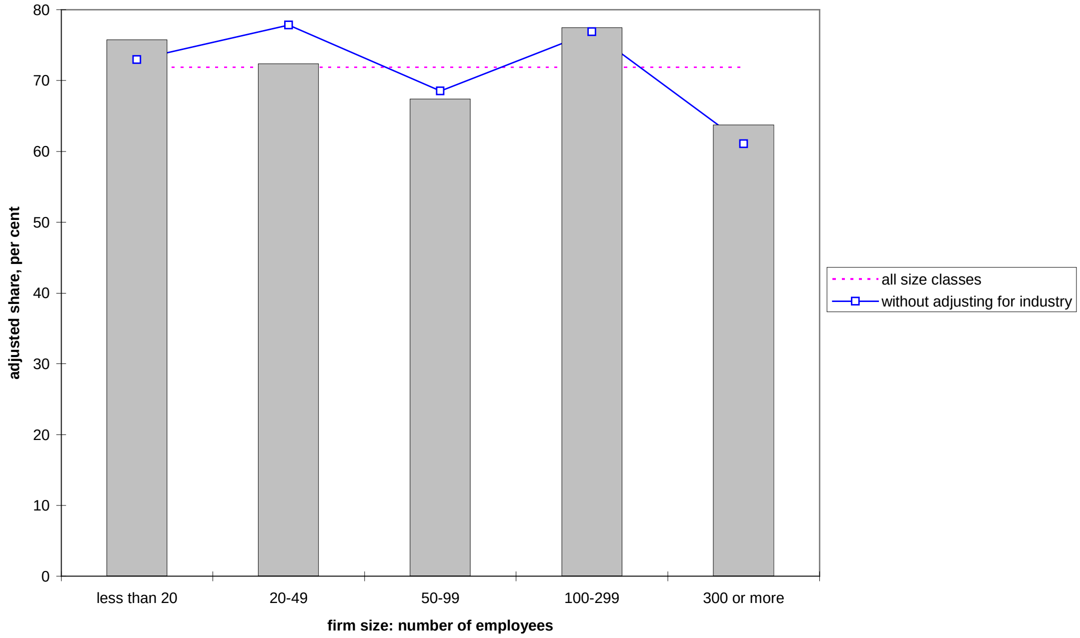


In the figure, we have also shown the adjusted shares we found when we controlled only for number of ways reported, as well as the share for the total (the weighted average).

This time we find that only one of the ten differences are significant at the 5 per cent level, while when we controlled only for number of ways reported we found that three of the differences were. Figure 5 shows that the picture we get when we control for industry is almost identical to the one we get when we only control for number of ways reported but generally the adjusted shares tend to lie a little bit closer to the share of the total when we also control for industry. Thus, in this case we find that the only significant difference between size classes is that the 50-99 employees category has a significantly higher adjusted share than the 100-299 employees category.

For way of technology acquisition *e*, *purchase of equipment*, where we did find a couple of significant differences between size classes when we only controlled for number of ways reported, we find none when we also control for industry. The adjusted shares for *purchase of equipment* when controlling for industry and number of ways reported are shown in Figure 6, below.

Figure 6. **Controlling for industry. Share of the firms inside each size category who have acquired new technology through purchase of equipment, adjusted for differences in number of ways reported and for differences in distribution across industries**.



Again the adjusted shares we found when we controlled only for number of ways reported, as well as the share for the total (the weighted average), are also shown.

In this case, too, the picture changes very little when we control also for industry instead of only for number of ways reported. However, especially the share of the 300 or more employees category has moved a little bit closer to the share of the total, and so none of the differences between size classes become significant.

Thus, controlling for industry does not alter in any significant way the conclusion that we do not find any important differences across size classes regarding the relative importance of the different ways of technology acquisition.

However, there is a possibility that there is substantial statistical interaction present here, so that to a clear and consistent pattern of differences across size classes in some industries there corresponds an opposite pattern in other industries, these two these two opposing tendencies cancelling each other out when we examine all industries together. To examine this hypothesis, we looked at the differences across size classes in the share of each way of technology acquisition, controlling for number of ways reported, *inside each industry*. However, this time we looked for *linear* relationships between size and relative share of each way of technology acquisition. Thus, we used the five category size class variable as a *quantitative* variable and transformed the number of ways reported variable into six dummy variables and ran this regression for all of the 15 industries separately. The result was that we found size class coefficients which were statistically significant from zero, at the 5 per cent significance level (two tailed test) in four of the 15 industries: in two of these industries for two of the ways of technology acquisition, in the other two for one way only. This is far too little to support an hypothesis of a consistent pattern. Very likely we are only dealing with random variation here. Thus, the statistical interaction hypothesis is not confirmed. Consequently, it gives no support for altering the conclusion that we find no important differences across size classes.

Lastly, a word should be said about the differences across *industries* in the relative importance of the different ways of technology acquisition. The fact that controlling for industry does not affect in any significant way the differences across size classes does *not* mean that there are no important differences across industries. For each of the eight ways of technology acquisition we performed a three-way analysis of variance (ANOVA), with industry, size class and number of ways reported as independent class variables. We found that for three of the eight ways of technology acquisition the industry variable was significant (at the 5 % significance level). These three ways were 'R&D contracted out', 'purchase of other companies' and 'purchase of equipment'. Especially for 'purchase of equipment' the industry variable was highly significant indeed. This is interesting because the relative importance of purchase of equipment one would expect to be the variable here which is the best indicator of whether the dominant mode of innovation in a group of firms is 'embodied' or 'disembodied', 'passive' or 'active'. Where the relative importance of 'purchase of equipment' is high, one would expect an 'embodied' or more 'passive' mode to be predominant, where the importance of 'purchase of equipment' is low, a 'disembodied' or more 'active' way. I will not go further into an analysis of differences across *industries* in this paper.

9. Conclusion

The present paper has analysed differences across size categories in the acquisition of new technology among manufacturing firms. The data are from the Norwegian innovation survey 1993. The measure of technology acquisition is very rough and imperfect, only registering whether the firms have or have not acquired new technology through a number of specified ways in the course of one year, 1992.

The analysis has been divided into two. First, the overall 'level' of technology acquisition has been examined, then the relative importance of different ways of acquisition.

1. When it comes to the 'level' of activity in this respect there seems to be a very clear and strong tendency for the share of firms who have acquired new technology to increase with increasing firm size. Also, among the firms who have acquired new technology the average number of ways reported tends to increase with increasing firm size. These differences probably to a large extent reflect real differences, but they also probably reflect a certain bias in these 'mere occurrence' measures, to the effect that they will make large firms appear somewhat more innovative than small firms also in the case where they in fact are equally innovative.

2. Given these differences in 'level', we do *not* find any important differences across size categories when it comes to the *relative* importance of different *ways* of acquisition of new technology. For instance, the data do *not* show that one way of acquiring new technology is more important among small firms while another way is relatively more important among large firms. This result holds also when we control for differences in the industry distribution of firms across size classes.

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STEP-gruppen ble etablert i 1991 for å forsyne beslutningstakere med forskning knyttet til alle sider ved innovasjon og teknologisk endring, med særlig vekt på forholdet mellom innovasjon, økonomisk vekst og de samfunnsmessige omgivelser. Basis for gruppens arbeid er erkjennelsen av at utviklingen innen vitenskap og teknologi er fundamental for økonomisk vekst. Det gjenstår likevel mange uløste problemer omkring hvordan prosessen med vitenskapelig og teknologisk endring forløper, og hvordan denne prosessen får samfunnsmessige og økonomiske konsekvenser. Forståelse av denne prosessen er av stor betydning for utformingen og iverksettelsen av forsknings-, teknologi- og innovasjonspolitikken. Forskningen i STEP-gruppen er derfor sentrert omkring historiske, økonomiske, sosiologiske og organisatoriske spørsmål som er relevante for de brede feltene innovasjonspolitikk og økonomisk vekst.

The STEP-group was established in 1991 to support policy-makers with research on all aspects of innovation and technological change, with particular emphasis on the relationships between innovation, economic growth and the social context. The basis of the group's work is the recognition that science, technology and innovation are fundamental to economic growth; yet there remain many unresolved problems about how the processes of scientific and technological change actually occur, and about how they have social and economic impacts. Resolving such problems is central to the formation and implementation of science, technology and innovation policy. The research of the STEP group centres on historical, economic, social and organisational issues relevant for broad fields of innovation policy and economic growth.